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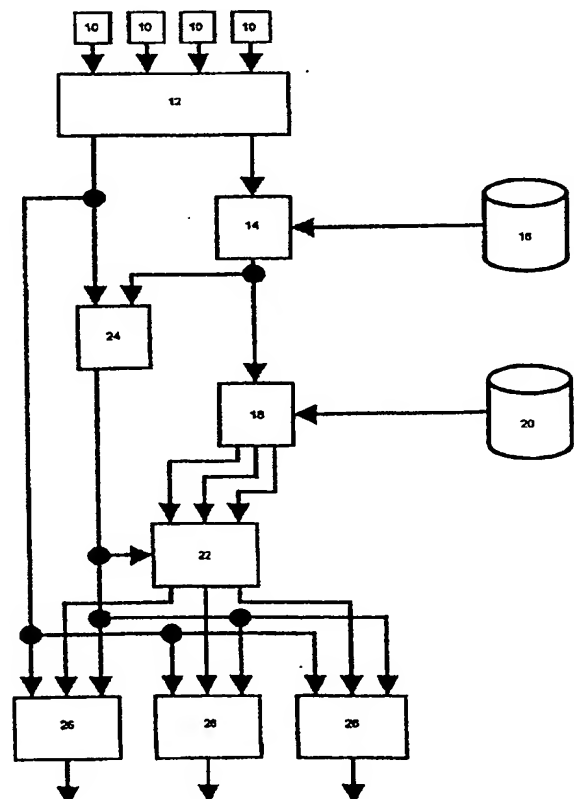
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(54) Title: METHODS AND APPARATUS FOR PRODUCING COMPOSITE VIDEO IMAGES

(57) Abstract

A system for automatically generating and adding secondary video images (such as advertising material) to primary video images or real world scenes (such as a live sports event) in such a way that the secondary image appears to be physically present in the scene represented by the primary image when the composite image is viewed subsequently. A "live" image from one of a number of cameras (10) is selected by an editing desk (12) for transmission. Prior to transmission, a secondary image is selected from a database (20) for inclusion in the final image, such that it appears superimposed on a physical target space in the first image. The selected image is transformed in terms of size, shape, orientation and lighting effects before being combined with the primary image. The transformation is based on a computed "expected image", which is derived from a computer model (16) of the environment containing the first image (such as a sports arena) and data transmitted from the camera regarding its location, orientation, focal length, etc. The expected image is matched with the first image in a matching module (24) to refine the alignment of the computed target space with the actual target space, and to identify lighting variations and foreground objects in the first image and apply these to the second image as seen in the final composite image. Multiple composite images may be generated including different secondary images so that, for example, different advertisements can be included in different composite images for transmission to different audiences.



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1 "Methods and Apparatus for Producing Composite Video
2 Images"

3
4 The present invention relates to a system for
5 automatically generating and adding secondary images to
6 primary images of real world scenes in such a way that
7 the secondary image appears to be physically present in
8 the scene represented by the primary image when the
9 composite image is viewed subsequently.

10
11 It is particularly envisaged that the invention be
12 applied to the presentation of advertising material
13 (secondary images) within primary images including, but
14 not limited to, television broadcasts, video
15 recordings, cable television programmes and films. It
16 is applicable to all video/TV formats, including
17 analogue and digital video, PAL, NTSC, SECAM and HDTV.
18 This type of advertising is particularly applicable to,
19 but is not limited to, live broadcasts of sports
20 events, programmes of highlights of sports events,
21 videos of sports events, live broadcasts of important
22 state events, television broadcasts of "pop" concerts
23 etc.

24
25 Prior practice relating to the placement of

1 advertisements within scenes represented in TV/video
2 images includes:

3 physical advertising hoardings which can be placed
4 at appropriate places in a scene or venue such that
5 they sometimes appear in the images; such hoardings can
6 be either simple printed signs or electromechanical
7 devices allowing the display of several fixed
8 advertisements consecutively;

9 advertisements which are placed directly onto
10 surfaces within the scene, for example, by being
11 painted onto the outfield at a cricket match, or by
12 being placed on players' clothes or by being painted
13 onto racing car bodies;

14 small fixed advertisements, for example, company
15 logos, which are simply superimposed on the image of
16 the scene.

17

18 These methods have the following disadvantages:

19 each physical advertising hoarding can present, at
20 most, a few static images; it cannot be substantially
21 varied during the event, nor can its image be changed
22 after the event other than by a painstaking manual
23 process of editing individual images;

24 advertisements made, for example, on playing
25 surfaces or on participants clothing, have to be
26 relatively discreet otherwise they intrude too much
27 into the event itself;

28 fixed advertisements, such as company logos,
29 superimposed on the image, look artificial and
30 intrusive since they are obviously not part of the
31 scene being viewed.

32

33 The present invention concerns a system whereby
34 secondary images, such as advertising material, can be
35 combined electronically with, for example, a live
36 action video sequence in such a manner that the

1 secondary image appears in the final composite image as
2 a natural part of the original scene. For example, the
3 secondary image may appear to be located on a hoarding,
4 while the hoarding in the original scene contains
5 different material or is blank. This allows, for
6 example, different advertising material to be
7 incorporated into the scene to suit different broadcast
8 audiences.

9
10 Numerous systems exist for combining video images for
11 various purposes. The prior art in this field includes
12 the use of "colour keying" (also known as "chroma
13 keying") in which a foreground object, such as a
14 weather forecaster, is in front of a uniform background
15 of a single "key" colour. A second video source
16 provides another signal, such as a weather map. The
17 two video signals are mixed together so that the second
18 video signal replaces all parts of the first video
19 signal which have the key colour. A similar approach
20 is employed in "pattern-keying". Alternatively, of
21 course, individual frames of the primary image could be
22 edited manually to include the secondary image.

23
24 It has previously been proposed to use video systems of
25 this general type to insert advertising material into
26 video images, one example being disclosed in
27 WO93/02524. WO93/06691 discloses a system having
28 similar capabilities.

29
30 Colour keying works well in very restricted
31 circumstances where the constituent images can be
32 closely controlled, such as in weather forecasting or
33 pre-recorded studio productions. However, it does not
34 work in the general case where it is desired to mix
35 unrestricted background images in parts of unrestricted
36 primary images. The same applies generally to pattern-

1 keying systems. Replacing physical advertising signs
2 by manually editing series of images is not feasible
3 for live broadcasts and is extremely costly even for
4 use with recorded programmes.

5
6 Existing systems such as these are not well suited for
7 the purposes of the present invention. Even where
8 prior proposals relate specifically to the insertion of
9 advertising material in video images, such proposals
10 have not addressed one or more issues such as coping
11 with foreground objects or with lighting effects or
12 with multiple cameras.

13
14 In accordance with a first aspect of the present
15 invention there is provided a method of modifying a
16 first video image of a real world scene to include a
17 second video image, such that said second image appears
18 to be superimposed on the surface of an object
19 appearing within said first image, wherein said second
20 image is derived by transforming a preliminary second
21 image to match the size, shape and orientation of said
22 surface as seen in said first image and said second
23 image is combined with said first image to produce a
24 composite final image;

25 said method including:

26 a preliminary step of constructing a three-
27 dimensional computer model of the environment
28 containing the real world scene, said model including
29 at least one target space within said environment upon
30 which said second image is to be superimposed;

31 generating camera data defining at least the
32 location, orientation and focal length of a camera
33 generating said first image; and

34 transforming the preliminary second image on the
35 basis of said model and said camera data so as to match
36 said target space as seen in the first image, prior to

1 combining said first image and said second image.

2

3 In accordance with a second aspect of the invention
4 there is provided apparatus for generating a composite
5 video image comprising a combination of a first video
6 image of a real world scene and a second video image,
7 such that said second image appears to be superimposed
8 on the surface of an object appearing within said first
9 image, including:

10 at least one camera for generating said first
11 image;

12 means for generating said second image by
13 transforming a preliminary second image to match the
14 size, shape and orientation of said surface as seen in
15 said first image; and

16 means for combining said second image with said
17 first image to produce a composite final image;

18 said apparatus including:

19 means for storing a three-dimensional computer
20 model of the environment containing the real world
21 scene, said model including at least one target space
22 within said environment upon which said second image is
23 to be superimposed;

24 means for generating camera data defining at least
25 the location, orientation and focal length of a camera
26 generating said first image; and

27 means for transforming the preliminary second
28 image on the basis of said model and said camera data
29 so as to match said target space as seen in the first
30 image, prior to combining said first image and said
31 second image.

32

33 Further aspects and preferred features of the invention
34 are defined in the Claims appended hereto.

35

36 Embodiments of the invention will now be described, by

1 way of example only, with reference to the accompanying
2 drawing, which is a schematic block diagram of a system
3 embodying the invention.

4
5 The overall scheme of the invention is illustrated in
6 the drawing. One or more cameras 10 are deployed to
7 provide video coverage of an event in a venue, such as
8 a sporting arena (not shown). The following discussion
9 relates particularly to "live" coverage, but it will be
10 understood that the invention is equally applicable to
11 processing pre-recorded video images and associated
12 data.

13
14 Each of the cameras 10 is augmented by the addition of
15 a hardware module (not shown) adapted to generate
16 signals containing additional data about the camera,
17 including position and viewing direction in three
18 dimensions, and lens focal length. A wide variety of
19 known devices may be used for providing data about the
20 orientation of a camera (e.g. inclinometers,
21 accelerometers, rotary encoders etc.), as will be
22 readily apparent to those of ordinary skill in the art.

23
24 The video signal from each camera 10 in operation at a
25 particular event is passed to an editing desk 12 as
26 normal, where the signal to be transmitted is selected
27 from among the signals from the various cameras.

28
29 The additional camera data is passed to a modelling
30 module (computer) 14 which has access to a predefined,
31 digital 3-d model of the venue 16. The venue model 16
32 contains representations of all aspects of the venue
33 which are significant for operation of the system,
34 typically including the camera positions and the
35 locations, shapes and sizes of prominent venue features
36 and all "target spaces" onto which secondary images are

1 to be superimposed by the system, such as physical
2 advertising hoardings.

3

4 The modelling module 14 uses the camera location,
5 orientation and focal length data to compute an
6 approximation of the image expected from the camera 10
7 based on transformed versions of items forming part of
8 the model 16 which are visible in the camera's current
9 view.

10

11 The modelling module 14 also calculates a pose vector
12 relative to the camera view vector for each of the
13 target spaces visible in the image. Target spaces into
14 which the system is required to insert secondary images
15 are referred to herein as "designated targets".

16

17 The additional camera data is also passed to the
18 secondary image generation module 18 which generates a
19 preliminary secondary image for each designated target
20 in the primary image. A library of secondary images is
21 suitably stored in a secondary image database 20,
22 accessible by the secondary image generation module 18.

23

24 The pose of each of the designated targets, derived
25 from the "expected view" calculated by the modelling
26 module 14, is fed into a transformation module 22
27 together with the preliminary secondary images. The
28 preliminary secondary images are transformed by the
29 transformation module 22 so that they have the correct
30 perspective appearance (size, shape and orientation) to
31 match the corresponding target space as viewed by the
32 camera 10.

33

34 The original video image and the expected image
35 calculated from the 3-d model 16 are both also passed
36 to a matching module 24. The matching module 24

1 effectively superimposes the calculated expected image
2 over the actual image as a basis for matching the two.
3 It identifies as many as possible of the corners and
4 edges of the target spaces corresponding to the
5 designated targets and any other items of the venue
6 model 16 present in the expected image. It uses these
7 matches to refine the transformational match of the
8 expected image to the actual image. Finally, the
9 matcher extracts any foreground objects and lighting
10 effects from the image areas of the designated targets.

11
12 The original primary image from the editing desk 12,
13 the transformed secondary image and the output data
14 from the matching module 24 are passed to one or more
15 output modules 26 where they are combined to produce a
16 final composite video output, in which the primary and
17 secondary images are combined. There may be multiple
18 output modules 26, each inserting different secondary
19 images into the same primary images.

20
21 Obviously, for live transmission, this whole procedure
22 has to happen in real time. Fortunately, the state of
23 modern computing and image processing technology is
24 such that the necessary hardware is not particularly
25 expensive.

26
27 Each of the modules mentioned above is described in
28 more detail below.

29
30 Camera Augmentation

31
32 Each camera is equipped with a device which
33 continuously transmits additional camera data to the
34 central station. This camera data could either be
35 transmitted via a separate means such as additional
36 cables or radio links, or could be incorporated into

1 the hidden parts of the video signal in the same way as
2 teletext information. Methods and means for
3 transmitting such data are well known.

4

5 This camera data typically includes some or all of:

6 a camera identifier;

7 the camera position;

8 the camera orientation;

9 the lens focal length;

10 the lens focusing distance;

11 the camera aperture.

12

13 The camera identifier is a string of characters which
14 uniquely identifies each camera in use. The camera
15 position is a set of three coordinate values giving the
16 position of the camera in the coordinate system in use
17 in the 3-d venue model. The camera orientation is
18 another set of three values, defining the direction in
19 which the camera is pointing. For example, this could
20 be made up of three angles defining the camera viewing
21 direction in the coordinate system used to define the
22 camera position. The coordinate system used is not
23 critical as long as all the cameras in use at a
24 particular event supply the camera data in a way which
25 is understood by the modelling and transformation
26 modules.

27

28 Since most cameras are fitted with zoom lenses, the
29 lens focal length is required to define the scene for
30 the purposes of secondary image transformation. The
31 lens focusing distance and camera aperture are also
32 required to define the scene for the purposes of
33 transforming the secondary image in terms of which
34 parts of the scene are in focus.

35

36 The additional devices with which each camera is

1 equipped may depend on the role of the camera. For
2 example, a particular camera may be fixed in position
3 but adjustable in orientation. In this case, a
4 calibration procedure may be used which results in an
5 operator entering the camera's position into the device
6 before the event starts. The orientation would be
7 determined continuously by the device as would the
8 focal length, focusing distance and aperture.

9
10 The Venue Model

11
12 Key elements at the venue are represented within the
13 general 3-d venue model 16.

14
15 The model may be based on a normal orthogonal 3-d
16 coordinate system. The coordinate system origin used
17 at a particular venue may be global or local in nature.
18 For example, if the venue is a soccer stadium, it may
19 be convenient to take the centre spot as the origin and
20 to take the half-way line to define one axis direction,
21 with an imaginary line running down the centre of the
22 pitch defining a second axis direction. The third axis
23 would then be a vertical line through the centre spot.

24
25 Each relevant permanent item of the venue is
26 represented within the model in a way which
27 encapsulates the item's important features for the
28 purposes of the present system. Again, in the example
29 of the soccer stadium, this could include:

30 the playing surface, represented as a planar
31 surface with particular surface markings and a
32 particular texture;
33 goalposts, represented as a solid object, for
34 example, as the intersection of several cylindrical
35 objects, having specific surface properties, e.g. white
36 colour;

1 goal nets, which may be represented as an
2 intersection of curvilinear objects with specific
3 surface properties and having the property of
4 flexibility;

5 advertising hoardings, which, in the simplest
6 case, are represented as planar surfaces with complex
7 surface properties, i.e. the physical advertisement
8 (it is preferable that the surface properties are
9 stored using a scale-invariant representation in order
10 to simplify the matching process);

11 prominent permanent venue features: it is useful
12 to the matching process if prominent features are
13 included in the venue model; these may be stored as
14 solid objects with surface properties (for example, if
15 a grandstand contains a series of vertical pillars,
16 then these could be used in the matching process to
17 improve the accuracy of the process).

18
19 The methods and means for generating and using 3-d
20 models, such as the venue model described above, and
21 for determining the positions of objects within such
22 models are all well known from other applications such
23 as virtual reality modelling.

24 25 Overall Signal Processing

26
27 The object of the signal processing performed by the
28 system is to identify the position of the designated
29 targets in the current image, to extract any foreground
30 objects and lighting effects relevant to the designated
31 targets, then to generate secondary images and insert
32 them into the current primary image in place of the
33 designated targets such that they look completely
34 natural. The signal processing takes place in the
35 following stages.

- 1 1. Use the camera data in conjunction with the venue
2 model to generate an expected image incorporating all
3 the objects in the venue model which are expected to be
4 seen in the actual image and to calculate the pose of
5 each of the visible designated targets relative to the
6 camera (modelling module 14).
- 7 2. Identify as many as possible of the expected
8 objects in the actual image (matching module 24).
- 9 3. Use the individual item matches to refine the view
10 details of the expected image (matching module).
- 11 4. Project the borders of the designated targets onto
12 the real image and refine the border positions, where
13 appropriate with reference to edges and corners in the
14 actual image (matching module 24).
- 15 5. Match the expected designated target image to the
16 corresponding region in the actual image, the match to
17 be performed separately in colour space and intensity
18 space. Any missing regions in the colour space match
19 are assumed to be foreground objects. The bounding
20 subregion of the target region is extracted and stored.
21 The stored region includes colour and intensity
22 information. Any mismatch regions occurring in
23 intensity space only, e.g. shadows, which are not part
24 of foreground objects are extracted and stored as
25 intensity variations (matching module 24).
- 26 6. Store the outcome of the matching process for use
27 in matching the next frame.
- 28 7. Transform the scale-invariant designated target
29 model to fit the best estimate bounding region
30 (transform module 22).
- 31 8. Reassemble as many outgoing video signals as
32 required by inserting the transformed secondary images
33 into the original primary image and then reinserting
34 foreground objects and lighting effects (output
35 module).
- 36

1 Matching Module

2

3 The matching module 24 has several related functions.

4

5 The matcher first compares the expected view with the
6 actual image to match corners and edges of items in the
7 expected view with corresponding corners and edges in
8 the actual image. This is greatly simplified by the
9 fact that the expected image should be very close to
10 the same view of the scene as the actual image. The
11 object of this phase of matching is to correlate
12 regions of the actual image with designated targets in
13 the expected image. Corners are particularly
14 beneficial in this part of the process since a corner
15 match provides two constraints on the overall
16 transformation whilst an edge match provides only one.
17 Since the colour of the objects in the expected image
18 is known from their representation in the venue model,
19 this provides a further important clue in the matching
20 process. When as many as possible of the corners and
21 edges of the objects in the expected image have been
22 matched to corners and edges in the actual image, a
23 consistency check is carried out and any individual
24 matches which are inconsistent with the overall
25 transformation are rejected. Matching corners and
26 edges in this way is a method well established in
27 machine vision applications.

28

29 The outcome of the first phase of matching is a
30 detailed mapping of the expected image onto the actual
31 image. The second stage of matching is to deal with
32 each designated target in turn to identify its exact
33 boundary in the image and any foreground objects or
34 lighting effects affecting the appearance of the
35 corresponding physical object or area in the original
36 image. This is done by using the corner and edge

1 matches and interpolating any missing sections of the
2 boundary of the original object/area using the
3 projected boundary of the designated target. For
4 example, if the designated target is a rectangular
5 advertising hoarding, then as long as sufficient
6 segments of the boundary of the hoarding are
7 identified, the position of the remaining segments can
8 be calculated using the known segments and the known
9 shape and size of the hoarding together with the known
10 transformation into the image.

11
12 The final stage of the matching process involves
13 identifying foreground objects and lighting effects
14 within the region of each designated target. This is
15 based on transforming the scale invariant
16 representation of the designated target in the venue
17 model such that it fits exactly the bounding region of
18 the corresponding ad in the original image. A match in
19 colour space is then carried out within the bounding
20 region to identify sections of the image which do not
21 match the corresponding sections of the transformed
22 model. These non-matching sections are taken to be
23 foreground objects and these parts of the image are
24 extracted and stored to be superimposed on top of the
25 transformed secondary image in the final composite
26 image. A match in intensity space is also carried out
27 to identify intensity variations which are not part of
28 the original object/area. These are considered to be
29 lighting effects and an intensity transformation is
30 used to extract these and keep them for later use in
31 transforming the secondary image.

32
33 Hence, the output from the matching process includes:
34 the exact image boundary of all the designated
35 targets;
36 foreground objects in any of these regions; and

1 lighting effects in any of these regions.

2

3 Secondary Image Generation Module

4

5 One of the major advantages of using electronically
6 generated secondary images rather than physical signs
7 is in the extra scope for controlling the choice,
8 positioning and content of the secondary image, e.g. an
9 advertising message.

10

11 Generation of the secondary images uses a database 20
12 of secondary image material. In addition to the actual
13 secondary images, stored as scale-invariant
14 representations, this database may include information
15 such as:

16 the percentage of the available advertising space-
17 time has been booked by each advertiser;

18 any preferences on which part of the event's
19 duration and which part of the venue are to be used for
20 each advertiser;

21 associations of particular secondary images with
22 potential occurrences in the event being covered.

23

24 Another strength of the use of electronically
25 integrated secondary images is the ability to generate
26 different video outputs for different customers.

27 Hence, in an international event, different advertising
28 material could be inserted into the video signal going
29 to different countries. For example, say the USA is
30 playing China at basketball. Most Americans don't read
31 Chinese and most Chinese don't read English. So the
32 transmission to China would include only advertisements
33 in Chinese, while the broadcast in the USA would
34 include only english language advertisements.

35

36 Generating a particular advertisement for display in

1 the present system may take place in the following
2 stages:

3 choose the company whose advertisement will be
4 displayed;

5 choose which of the selected company's
6 advertisements is appropriate for the current context;

7 transform the stored representation of the
8 selected advertisement to match the available region of
9 the image.

10

11 For the first stage of this process, the selection of
12 the advertiser, the destination of the video signal
13 concerned is first determined. This indexes the
14 advertisers for the output module 26 corresponding to
15 that destination. Next, a check is made to see how
16 much advertising time each advertiser has had during
17 the event so far relative to how much they have booked.
18 The advertiser is selected on this basis, taking
19 account of advertiser preferences such as location and
20 timing.

21

22 The next stage, the selection of one advertisement from
23 a set supplied by the advertiser to replace a
24 designated target in the original image, is based on
25 factors including:

26 the size of the space available;

27 the location of the designated target;

28 the phase of the event;

29 any notable occurrences during the event.

30

31 For example, an advertiser may choose to supply some
32 advertisements containing a lot of detail and some
33 which are very simple. If the space available is
34 large, perhaps because the camera concerned is showing
35 a close up of a soccer player about to take a corner
36 and the advertising space available fills a large part

1 of the image, then it may be appropriate to fit a more
2 detailed advertisement where the details will be
3 visible. At the other extreme, if a particular camera
4 is showing a long view, then it may be better to select
5 a very simple advertisement with strong graphics so
6 that the advertisement is legible on the screen.

7
8 Note also that the selection of advertisements can be
9 influenced by what has happened in the event. For
10 example, say a particular player, X, has just scored a
11 goal. Then an advertiser who manufactures drink, Y, may
12 want to display something to the effect that "X drinks
13 Y". To meet this need the system has the capability to
14 store advertisements which are only active (i.e.
15 available for selection) when a particular event has
16 taken place. Additionally, these advertisements can
17 have place holders where the name of a participant or
18 some other details can be entered when the ad is made
19 active. This could be useful if drinks advertiser Y
20 has a contract with a whole team. Then when any team
21 member does something exceptional, that team member's
22 name, or other designation, could be inserted into the
23 advertisement.

24
25 Note also that there is no restriction on
26 advertisements being static. As long as the
27 advertisement still looked as though it was part of the
28 event, it could be completely dynamic. For example, an
29 advertising video could be inserted into a suitable
30 designated target. One particular case might be where
31 the venue concerned has a large playback screen, such
32 as at many cricket and athletics events. The screen
33 would be used to show replays of the event to the
34 spectators present, but it could also be a designated
35 target for the present system. Such a screen would
36 then be a good candidate for showing video advertising

1 material.

2

3 A further aspect of the process of secondary image
4 generation relates to how to change images. Clearly,
5 if a camera is panning, then different secondary images
6 can be included as different parts of the venue come
7 into the image. Note that it is important to record
8 which secondary image is being displayed on which
9 designated target, since a cut from one camera to
10 another should not cause the secondary image to change
11 if the two cameras are capturing the same designated
12 target. It can also occur that one camera will be used
13 for a particularly long time and it and it may be
14 desirable to change the secondary images in the
15 composite image part way through the shot. This is
16 accomplished by simulating the change of a physical ad.
17 For example, there are physical advertising hoardings
18 available which are able to show more than one ad,
19 either by rotating a strip containing the ads or by
20 rotating some triangular segments, each of whose faces
21 contains portions of different ads. To change a
22 secondary image while it is in shot, the secondary
23 image generation process may simulate the operation of
24 a physical hoarding, for example, by appearing to
25 rotate segments of a hoarding to switch from one ad to
26 the next.

27

28 Transform Module

29

30 The pose of the physical advertising space relative to
31 the camera concerned is known from the additional
32 camera data and the 3-d venue model 16. Hence,
33 transforming the scale-invariant representation of the
34 chosen secondary image into a 2-d image region with the
35 correct perspective appearance is a straightforward
36 task. In addition to the pose being correct, the

1 secondary image has to fit the target space exactly.
2 The region bounding the space is supplied by the
3 matching process. Hence, transforming the ad involves:
4 using the additional camera data and 3-d venue
5 model 16 to calculate the perspective appearance of the
6 secondary image (this is done in the modelling module
7 14);
8 using the matching information to scale the
9 secondary image to fit the space available.

10

11 The secondary image is now ready to be dropped into the
12 original video image.

13

14 Output Module

15

16 One output module 26 is required for each outgoing
17 video signal. Hence, if the final of the World Cup is
18 being transmitted to 100 countries which have been
19 split into 10 areas for advertising, then ten output
20 modules would be required.

21

22 The output module 26 takes one set of secondary images
23 and inserts them into the original primary image. It
24 then takes the foreground object and lighting effects
25 generated by the matching process and reintegrates
26 them. In the case of the foreground objects, this
27 requires parts of the inserted secondary images to be
28 overwritten with the foreground objects. In the case
29 of lighting effects, such as shadows, the image
30 segments containing the secondary image must be
31 modified such that the secondary image looks as if it
32 is subjected to the same lighting effects as the
33 corresponding part of the original scene. This is done
34 by separating out the colour and intensity information
35 and modifying them appropriately. Methods for doing
36 this are well known in the field of computer graphics.

1 Use of the present invention has many benefits for
2 advertisers, particularly at large international
3 events. Some of these benefits are as follows:

4 different advertisements can be shown in different
5 countries or regions thereby improving targeting and
6 making sure that the advertising regulations of
7 individual countries, e.g. with respect to alcohol and
8 tobacco, are not violated;

9 each advertiser can be guaranteed a percentage of
10 the total exposure;

11 the detail of the advertisements can be adjusted
12 automatically based on their size in the TV image to
13 improve their legibility and impact;

14 there may be much greater creative scope in the
15 design of the advertisements;

16 by recording some extra information with the
17 individual camera video signals, different
18 advertisements can be used in subsequent use of the
19 original footage: for example, different advertisements
20 could be used in programmes of highlights than in live
21 broadcasts, and different advertisements again could be
22 used in subsequent video products.

23
24 Systems for replacing parts of video images with parts
25 of other images such that the replacement parts appear
26 to be a natural part of the original image are known in
27 the prior art. However, the systems described in the
28 prior art have serious limitations which are overcome
29 by the present invention.

30
31 One area of the prior art is based on colour or chroma
32 keying. This depends on being able to control the
33 colour of everything in the image and is not practical
34 as a general purpose system.

35
36 Another area of prior art involves a human operator

1 manually selecting the areas to be replaced and
2 performing various functions to deal with foreground
3 objects and lighting effects. This method is very time
4 consuming and expensive and obviously not applicable to
5 live broadcasts.

6
7 Another area of prior art specifies automatic
8 replacement of an advertising logo using the pose of
9 the identified logo to transform the virtual ad
10 (WO93/06691). However, this method does not describe
11 any way of dealing with foreground objects or lighting
12 effects.

13
14 The main advantages of the present invention over the
15 prior art are considered to be:

16 augmentation of cameras and the use of a full 3-d
17 venue model to enable generation of an expected image
18 and reliable and fast matching of the expected image to
19 an actual image without relying on colour keying or
20 extensive searching or analysis of the actual image;

21 use of the full 3-d venue model together with the
22 additional camera data to eliminate the need to
23 estimate the pose of physical ads from the image data;

24 separation of the video signal into colour and
25 intensity images for separate treatment of foreground
26 objects and lighting effects;

27 use of corner and edge detection and matching as
28 the basis for superimposing expected image segments
29 over actual image segments;

30 use of stored scale-invariant representations of
31 the physical designated targets to greatly simplify
32 identification of foreground objects and lighting
33 effects.

34

35 As a result of these improvements, the present
36 invention is much more generally applicable than those

1 based on the prior art.
2
3 Improvements and modifications may be incorporated
4 without departing from the scope of the invention.
5

1 Claims

2

3 1. A method of modifying a first video image of a
4 real world scene to include a second video image, such
5 that said second image appears to be superimposed on
6 the surface of an object appearing within said first
7 image, wherein said second image is derived by
8 transforming a preliminary second image to match the
9 size, shape and orientation of said surface as seen in
10 said first image and said second image is combined with
11 said first image to produce a composite final image;

12 said method including:

13 a preliminary step of constructing a three-
14 dimensional computer model of the environment
15 containing the real world scene, said model including
16 at least one target space within said environment upon
17 which said second image is to be superimposed;

18 generating camera data defining at least the
19 location, orientation and focal length of a camera
20 generating said first image; and

21 transforming the preliminary second image on the
22 basis of said model and said camera data so as to match
23 said target space as seen in the first image, prior to
24 combining said first image and said second image.

25

26 2. A method as claimed in Claim 1, wherein the
27 transformation of the preliminary second image includes
28 manipulation thereof to take account of lighting
29 conditions in the image of the real world scene.

30

31 3. A method as claimed in Claim 2, wherein objects
32 included in said model are matched with corresponding
33 regions of said first image, intensity information
34 relating to matched objects is compared with intensity
35 information relating to said corresponding image
36 region, regions of intensity mismatch within said

1 corresponding regions are identified as lighting
2 variations and, when said second image is transformed,
3 the intensity of portions thereof is varied on the
4 basis of said regions of intensity mismatch so as to
5 simulate lighting variations within the first image.
6

7 4. A method as claimed in any preceding Claim,
8 wherein the combination of the first and second images
9 includes manipulation thereof to take account of
10 foreground objects in the image of the real world
11 scene.
12

13 5. A method as claimed in Claim 4, wherein objects
14 included in said model are matched with corresponding
15 regions of said first image, colour information
16 relating to matched objects is compared with colour
17 information relating to said corresponding image
18 region, regions of colour mismatch within said
19 corresponding regions are identified as foreground
20 objects and, when said first and second images are
21 combined, said first image is retained in preference to
22 said second image within said colour mismatch regions.
23

24 6. A method as claimed in any preceding Claim,
25 wherein said camera data and said computer model are
26 combined to compute a representation of the image
27 expected from the camera.
28

29 7. A method as claimed in Claim 6, wherein features
30 of said expected image are matched with features of
31 said first image.
32

33 8. A method as claimed in Claim 7, wherein said
34 matching of the expected image and the first image is
35 used to refine the boundary of the target space within
36 the expected image.

1 9. A method as claimed in Claim 8, wherein the
2 transformation of the shape, size and orientation of
3 the preliminary second image is based on said refined
4 target boundary.

5
6 10. A method as claimed in Claim 7, Claim 8 or Claim
7 9, wherein said matching of the expected image and the
8 first image includes comparison of colour and intensity
9 information for the purpose of identifying foreground
10 objects and lighting variations in said first image.

11
12 11. A method as claimed in any one of Claims 7 to 10,
13 wherein said first image and said second image are
14 combined on the basis of said matching of features
15 between the expected image and the first image.

16
17 12. A method as claimed in any one of Claims 7 to 11,
18 wherein said computer model includes scale-invariant
19 colour representations of surface properties of said
20 target spaces and said expected image incorporates said
21 colour representations of said target spaces.

22
23 13. A method as claimed in any preceding Claim,
24 wherein said first video image is a live action video
25 image and said composite image is generated in real
26 time.

27
28 14. A method as claimed in any preceding Claim wherein
29 multiple second images are superimposed upon multiple
30 target spaces.

31
32 15. A method as claimed in any preceding Claim,
33 wherein multiple composite images are generated, each
34 comprising the same first image combined with differing
35 second images.

36

1 16. A method as claimed in any preceding Claim,
2 wherein said second image is selected automatically
3 from a plurality of images, in accordance with
4 predetermined selection criteria.

5
6 17. A method as claimed in any preceding Claim,
7 wherein said first image is selected from a plurality
8 of video images generated by a plurality of cameras.

9
10 18. Apparatus for generating a composite video image
11 comprising a combination of a first video image of a
12 real world scene and a second video image, such that
13 said second image appears to be superimposed on the
14 surface of an object appearing within said first image,
15 including:

16 at least one camera for generating said first
17 image;

18 means for generating said second image by
19 transforming a preliminary second image to match the
20 size, shape and orientation of said surface as seen in
21 said first image; and

22 means for combining said second image with said
23 first image to produce a composite final image;

24 said apparatus including:

25 means for storing a three-dimensional computer
26 model of the environment containing the real world
27 scene, said model including at least one target space
28 within said environment upon which said second image is
29 to be superimposed;

30 means for generating camera data defining at least
31 the location, orientation and focal length of a camera
32 generating said first image; and

33 means for transforming the preliminary second
34 image on the basis of said model and said camera data
35 so as to match said target space as seen in the first
36 image, prior to combining said first image and said

1 second image.

2

3 19. Apparatus as claimed in Claim 18, wherein the
4 means for transforming the preliminary second image
5 includes means for manipulating said second image to
6 take account of lighting conditions in the first image
7 of the real world scene.

8

9 20. Apparatus as claimed in Claim 19, means for
10 matching objects included in said model with
11 corresponding regions of said first image, said
12 matching means including means for comparing intensity
13 information relating to matched objects with intensity
14 information relating to said corresponding image
15 region, and means for identifying regions of intensity
16 mismatch within said corresponding regions, and wherein
17 said image transforming means includes means for
18 varying the intensity of portions of said second image
19 on the basis of said regions of intensity mismatch so
20 as to simulate lighting variations within the first
21 image.

22

23 21. Apparatus as claimed in any one of Claims 18 to
24 20, wherein the means for combining the first and
25 second images includes means for manipulating said
26 second image to take account of foreground objects in
27 the image of the real world scene.

28

29 22. Apparatus as claimed in Claim 21, including means
30 for matching objects included in said model with
31 corresponding regions of said first image, said
32 matching means including means for comparing colour
33 information relating to matched objects with colour
34 information relating to said corresponding image
35 region, and means for identifying regions of colour
36 mismatch within said corresponding regions, and wherein

1 said image combining means includes means for
2 manipulating said second image such that, when said
3 first and second images are combined, said first image
4 is retained in preference to said second image within
5 said colour mismatch regions.

6
7 23. Apparatus as claimed in any one of Claims 18 to
8 22, including computer modelling means adapted to
9 compute a representation of the image expected from the
10 camera on the basis of said camera data and said
11 computer model.

12
13 24. Apparatus as claimed in Claim 23, including means
14 for matching features of said expected image with
15 features of said first image.

16
17 25. Apparatus as claimed in Claim 24, wherein said
18 means for matching the expected image and the first
19 image is further adapted to refine the boundary of the
20 target space within the expected image.

21
22 26. Apparatus as claimed in Claim 25, wherein the
23 image transformation means is adapted to effect
24 transformation of the shape, size and orientation of
25 the preliminary second image based on said refined
26 target boundary.

27
28 27. Apparatus as claimed in Claim 24, Claim 25 or
29 Claim 26, wherein said means for matching the expected
30 image and the first image includes means for comparing
31 colour and intensity information for the purpose of
32 identifying foreground objects and lighting variations
33 in said first image.

34
35 28. Apparatus as claimed in any one of Claims 24 to
36 27, wherein said means for combining said first image

1 and said second image are adapted to effect said
2 combination on the basis of said matching of features
3 between the expected image and the first image.
4

5 29. Apparatus as claimed in any one of Claims 24 to
6 28, wherein said computer model includes scale-
7 invariant colour representations of surface properties
8 of said target spaces and said modelling means is
9 adapted to generate expected images incorporating said
10 colour representations of said target spaces.
11

12 30. Apparatus as claimed in any one of Claims 18 to
13 29, wherein said first video image is a live action
14 video image and the apparatus is adapted to generate
15 said composite image in real time.
16

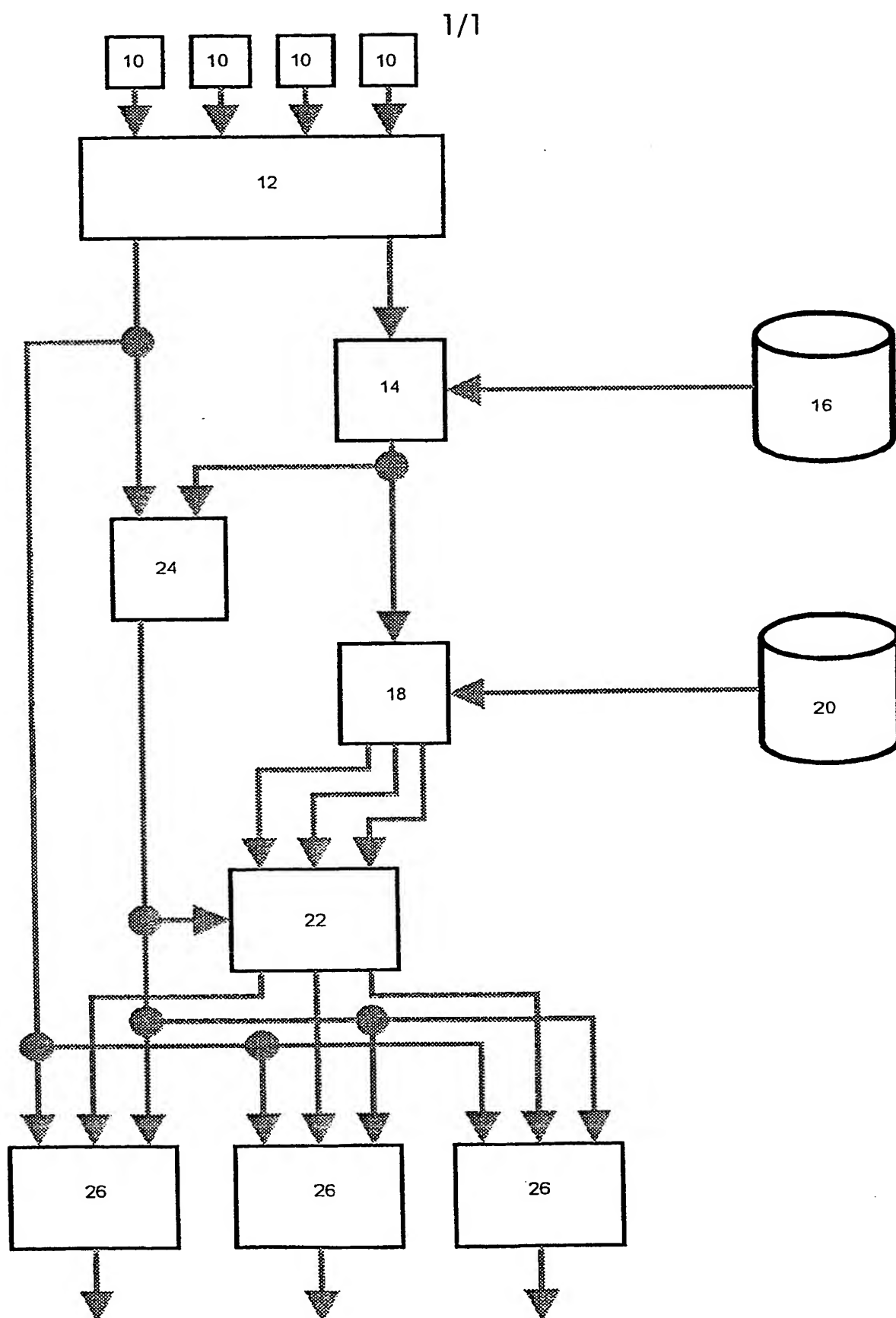
17 31. Apparatus as claimed in any one of Claims 18 to
18 30, wherein the apparatus is adapted to superimpose
19 multiple second images upon multiple target spaces.
20

21 32. Apparatus as claimed in any one of Claims 18 to
22 31, including multiple output means, each of said
23 output means being adapted to generate different
24 composite images, each of said different composite
25 images comprising the same first image combined with
26 differing second images.
27

28 33. Apparatus as claimed in any one of Claims 18 to
29 32, including means for storing a plurality of images
30 and means for automatically selecting said second image
31 from said plurality of images, in accordance with
32 predetermined selection criteria.
33

34 34. Apparatus as claimed in any one of Claims 18 to
35 33, wherein a plurality of cameras are connected to
36 video editing means and said first image is selected

- 1 from a plurality of video images generated by said
- 2 plurality of cameras.
- 3



INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 96/01682

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04N5/272 H04N5/262

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO,A,95 10919 (ORAD INC ;SHARIR AVI (IL); TAMIR MICHAEL (IL)) 20 April 1995 see page 3, line 4 - page 11, line 16 see page 15, line 4 - page 36, line 30; figures 1-18 ---	1-34
X	WO,A,93 06691 (SARNOFF DAVID RES CENTER) 1 April 1993 cited in the application ---	1,2,4,6, 7,10,11, 13,14, 17-19, 21,23, 24,27, 28,30, 31,34 3,5,9, 20,22,26
A	see page 7, line 34 - page 21, line 2; figures 4-7 --- -/--	



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

* Special categories of cited documents:

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Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 96/01682

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	US,A,5 491 517 (KREITMAN HAIM ET AL) 13 February 1996	1,2,4,6, 7,10,11, 13, 17-19, 21,23, 24,27, 28,30,34
P,A	see column 1, line 59 - column 3, line 44 see column 5, line 51 - column 6, line 2; figure 2 see column 6, line 50 - column 6, line 64; figures 1,2 see column 7, line 42 - column 8, line 54; figures 5-9 see column 12, line 59 - column 14, line 26; figures 18-21 -----	3,5,9, 14,20, 22,26, 31-33

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 96/01682

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		CA-A-	2119272	01-04-93
		EP-A-	0604572	06-07-94
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US-A-5491517	13-02-96	AU-A-	1933495	03-10-95
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